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Effects of the SPARK program on motor skills, physical fitness, and social skills in children and adolescents: a systematic review

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Abstract

Background The holistic health of children, encompassing physical, psychological, and social domains, plays a crucial role in long-term societal development. However, evidence suggests that many young people engage in insufficient physical activity, which may be associated with underdeveloped motor abilities and limited opportunities for social interaction. The SPARK program (Sports, Play, and Active Recreation for Kids) is a structured, evidence-based physical education curriculum designed to promote physical activity, cardiovascular fitness, and motor skill development. Despite its widespread use, comprehensive evaluations of its overall effectiveness remain limited.

Objective This review aimed to synthesize and evaluate existing empirical studies examining the effects of the SPARK program on children's and adolescents' physical fitness, motor development, and social skills.

Methods A systematic search was conducted across PubMed, Web of Science, EBSCOhost (CINAHL Plus, SPORTDiscus, Academic Search Complete), and Scopus up to June 5, 2025. Eligible studies included participants aged 3–18 years, implemented SPARK as the intervention, and met pre-established inclusion criteria. Methodological quality was appraised using the PEDro scale, risk of bias was assessed using RoB 2 or ROBINS-I, and certainty of evidence was graded according to the GRADE approach.

Results Nineteen quantitative studies met the inclusion criteria, including randomized controlled trials and quasi-experimental designs, and were primarily conducted in Iran and the United States. Overall methodological quality was moderate, with most studies exhibiting some or serious risk of bias related to non-random allocation and limited blinding. GRADE evaluations indicated moderate certainty of evidence for improvements in motor skills and low certainty of evidence for physical fitness and social adaptability. Positive trends were observed for cardiorespiratory fitness, muscular strength, and motor proficiency. Evidence related to BMI and flexibility outcomes was limited. Social skills were assessed in only two studies, both of which reported positive effects. Long-term evidence remains insufficient.

Conclusions The available evidence suggests that the SPARK program is associated with improvements in motor skill outcomes, supported by moderate-certainty evidence. In contrast, evidence for physical fitness and social

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outcomes remains limited and less conclusive. Further high-quality randomized controlled trials with larger, more diverse samples and extended follow-up periods are needed to strengthen confidence in these findings and clarify the sustainability of observed effects.

Keywords SPARK program, systematic review, motor skills, physical fitness, social skills, children and adolescents

Introduction

The World Health Organization (WHO) defines health as "a state of complete physical, mental, and social well-being, rather than merely the absence of disease or disability" [1]. From a developmental standpoint, children's health in these interconnected domains is closely related to how they function in daily life, how they learn, and how they develop over time [2]. A growing body of developmental research suggests that attention to physical, psychological, and social health during childhood is associated with more favorable outcomes later in life [3]. Early childhood, in particular, is widely regarded as a sensitive period for the development of fundamental motor skills (FMS) and the establishment of basic physical fitness. Numerous studies have reported associations between children's participation in physical activity and their motor skill performance [4], indicating that early motor development plays an important role in subsequent health and functional outcomes.

During this stage of development, children gradually acquire a range of fundamental motor skills, such as balance, locomotor movements, and object-control skills [5], while physical fitness also undergoes meaningful change. Regular participation in physical activity appears to support both motor skill development and physical fitness in children [6]. In contrast, lower levels of physical activity during early childhood have been linked to poorer motor competence and slower neuromuscular development. Fundamental motor skills are therefore commonly viewed as an important element of overall child development, given their associations with physical fitness, health-related behaviors, and aspects of cognitive and social functioning [7]. Evidence further suggests that higher motor competence is associated with indicators including cardiorespiratory fitness, muscular strength, and perceived physical competence [5, 8]. Taken together, these findings indicate that motor skills and physical fitness tend to develop in parallel during childhood, jointly contributing to children's ability to perform more complex movement tasks as they grow [9, 10].

Physical fitness has also been examined in relation to later health risk profiles. Studies in pediatric populations have reported associations between cardiorespiratory and muscular fitness and various cardiovascular risk markers [11]. Alongside physical and motor development, social skill acquisition represents a central component of children's psychosocial functioning. Social skills contribute to children's capacity to adapt to social contexts, establish and maintain peer relationships, and manage interpersonal demands across development [12, 13]. The preschool and early school years are often described as particularly important for the development of social competence [14], and previous research has linked social skills with outcomes such as school readiness, classroom adjustment, and academic performance [15]. Viewed together, motor skills, physical fitness, and social skills represent interrelated developmental domains that are influenced, at least in part, by children's engagement in physical activity.

Although physical activity is widely recognized as essential for healthy growth and development, population-level evidence consistently shows that activity levels among children and adolescents remain insufficient. Longitudinal studies have demonstrated a progressive reduction in physical activity as children transition into adolescence [16], alongside marked increases in the prevalence of overweight and obesity among school-aged youth between 1990 and 2021 [17]. Evidence from large-scale international surveillance systems, such as the Global School-based Student Health Survey (GSHS) and the Health Behaviour in School-Aged Children (HBSC) study, indicates that the majority of adolescents aged 13–15 years fail to achieve the World Health Organization guideline of at least 60 min of moderate-to-vigorous physical activity per day [18]. Insufficient physical activity has been linked to poorer physical fitness outcomes and reduced motor competence, and several studies indicate that many children do not achieve age-appropriate proficiency in fundamental movement skills by the early primary school years [19]. Similar patterns of suboptimal motor competence have been reported across different countries and age groups [20–23].

Beyond physical and motor outcomes, some children and adolescents also experience challenges in social and interpersonal functioning. Previous studies have reported associations between social skill difficulties and problems with peer interaction, cooperation, and group-based activities during childhood and adolescence [24, 25]. Although bullying and peer victimization have been widely examined in epidemiological research [26, 27], physical activity programs have also been considered as potential contexts for promoting positive social interaction and inclusion. Adaptive and inclusive physical activity interventions, for example, have been associated with benefits for children with disabilities, including increased participation, psychosocial well-being, and engagement

within school environments [28]. In addition, organized sports and structured physical activity programs have been linked to aspects of social skill development, such as cooperation, communication, and peer interaction [29–32]. These findings suggest that physical activity settings may provide opportunities to address multiple developmental domains simultaneously, although outcomes are likely to depend on program characteristics and participant needs [33, 34].

Within this broader context, the SPARK (Sports, Play, and Active Recreation for Kids) program is a structured, curriculum-based physical education approach that has been implemented in school settings for several decades. The SPARK program was designed to increase children's participation in physical activity through learner-centered instructional strategies, while also incorporating components aimed at improving cardiovascular fitness and fundamental motor skills [35, 36]. Developed in response to concerns about insufficient physical activity and declining fitness among young people [37], SPARK integrates games, sports, and active recreational activities within a standardized educational framework. In the United States, it has been widely adopted as a health-oriented physical education curriculum [38]. The early childhood version of the program (SPARK-EC) places particular emphasis on moderate-to-vigorous physical activity, motor learning, and social-emotional development during key developmental stages [39]. Individual studies have reported favorable outcomes associated with SPARK participation, including improvements in academic indicators [40], physical activity levels [41, 42], motor skills [43, 44], and selected fitness outcomes in children with disabilities [45].

Although the SPARK curriculum has been widely implemented and evaluated, the existing evidence base remains fragmented. Many primary studies have focused on specific outcome domains, such as motor skills or physical fitness, without considering outcomes across multiple aspects of child development within a single synthesis. To date, no systematic review has comprehensively examined the effects of the SPARK program across motor skills, physical fitness, and social skills within an integrated analytical framework. Furthermore, differences in study populations, intervention duration, and implementation characteristics have limited understanding of how SPARK-related outcomes may vary across groups and settings.

Accordingly, this systematic review aimed to synthesize available empirical evidence on the effects of the SPARK program on motor skills, physical fitness, and social functioning in children and adolescents. Specifically, this review sought to describe participant characteristics, summarize key intervention features and delivery patterns, and examine reported outcomes across different developmental domains. By integrating findings from existing studies, this review aims to clarify the current state of evidence regarding SPARK-based interventions and to identify gaps that may inform future research and practice.

Methods

Study design and registration

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards were followed in conducting this systematic review [46]. The review protocol (registration number: CRD420251023170) was prospectively recorded in the PROSPERO database.

The purpose of this evaluation was to compile data from studies assessing the Sport, Play, and Active Recreation for Kids (SPARK) program in physical education classrooms. The motor skills, physical fitness, social functioning, and, when reported, physical activity-related outcomes of children and adolescents were among the outcomes of interest.

Sources of information and search methodology

PubMed, Web of Science, Scopus, and EBSCOhost (CINAHL Plus with Full Text, SPORTDiscus with Full Text, and Academic Search Complete) were all searched thoroughly for relevant material. All records from the database's creation until June 5, 2025, were included in the searches; the year of publication was not limited. Only English-language, peer-reviewed journal articles with human subjects were taken into consideration.

The search method comprised phrases associated with target demographics, result domains, and the SPARK program. The following was the complete search string:

"SPARK" OR "Sports, Play, and Active Recreation for Kids program" OR "SPARK Early Childhood Program" OR "SPARK Physical Activity" OR "SPARK exercise program" AND "physical fitness" OR "health-related fitness" OR "cardiorespiratory" OR "BMI" OR "strength" OR "coordination" OR "agility" OR "balance" OR "flexibility" OR "fundamental motor skill*" OR "gross motor skill*" OR "social skill*" OR "social adaptability" OR "social-emotional" AND "child*" OR "early child*" OR "preschool*" OR "elementary" OR "adolescent*" OR "student*" OR "children with obesity".

Additional studies were identified via manual searches in Google Scholar and by screening reference lists of included articles (see S1 Checklist). All records were imported into EndNote, and duplicates were removed before screening.

Selection criteria

Study eligibility was determined using the PICOS framework [47].

Inclusion criteria were as follows:

(1) Participants: Children and adolescents aged 3–18 years, including typically developing children and those with obesity, autism spectrum disorder (ASD), or attention-deficit/hyperactivity disorder (ADHD), as well as children with controlled chronic conditions. Controlled chronic conditions were operationalized as physician-diagnosed conditions that were medically stable (e.g., asthma, type 1 diabetes, controlled epilepsy), without severe motor impairment or a medical contraindication that would preclude participation in structured physical activity.
(2) Interventions: School-based SPARK programs (e.g., structured games/activities, instructor training, or standardized SPARK lesson plans) delivered for at least four weeks, with a minimum frequency of two sessions per week and session duration of at least 30 minutes.
(3) Study design: Experimental studies, including randomized controlled trials (RCTs), quasi-experimental studies, controlled pre–post designs, or single-group pre–post studies.
(4) Outcomes: Studies reporting at least one relevant outcome related to physical fitness (e.g., strength, endurance, flexibility, agility, balance, coordination, body mass index), motor skills, physical activity levels, or social functioning (e.g., cooperation, communication, adaptability, teamwork).
(5) Publication type: Peer-reviewed, full-text original research articles published in English.

Exclusion criteria were:

(1) Participants younger than 3 years or older than 18 years, or those with severe physical or neurodevelopmental disorders associated with major motor limitations;
(2) Interventions not based on the SPARK physical education curriculum (e.g., academic SPARK programs or unstructured free play);
(3) Inadequate intervention dosage (<4 weeks or <2 sessions per week);
(4) Non-experimental designs or studies lacking relevant outcome measures;
(5) Non-English publications, abstracts only, reviews, commentaries, book chapters, or dissertations.

Study selection and data extraction

Two reviewers (LYP and RL) independently reviewed the titles, abstracts, and full texts of all retrieved articles according to predefined inclusion criteria. Disagreements arising during the review process were resolved through discussion, and a third reviewer (CSC) was consulted when consensus could not be reached. Final decisions regarding study inclusion were confirmed by a fourth author (SD).

Both reviewers (LYP and RL) independently extracted data using a standardized data extraction form. Information collected included authors, year of publication, country or region, study design, participant characteristics and sample size, as well as intervention details (including intervention duration, frequency, session length, and implementer). Additional extracted elements included primary outcomes, assessment time points, measurement tools, and outcome domains. Table 1 summarizes the extracted information. Where available, quantitative data such as group means and standard deviations or reported effect estimates were also collected for data synthesis. Any unresolved discrepancies during data extraction were addressed through consultation with a third reviewer (CSC).

Methodological quality was independently assessed by two reviewers (JLZ and KY) using the Physical Therapy Evidence Database (PEDro) scale. Disagreements were resolved through discussion, with adjudication by a third reviewer (CSC) when necessary. The PEDro scale is a well-established tool for assessing the internal validity and methodological rigor of randomized controlled trials and quasi-experimental studies [48].

Quality appraisal

The Physiotherapy Evidence Database (PEDro) criteria were used by two reviewers to independently assess the methodological quality of the included studies [49]. Ten of the eleven items in the PEDro framework contribute to the total score, which ranges from 0 to 10, with higher scores indicating greater methodological rigor. Any disagreements between reviewers were resolved through discussion or, when necessary, adjudication by a third reviewer. Based on PEDro scores, study quality was categorized as high (8–10), moderate (5–7), poor (3–4), or very low (< 3) [50]. The corresponding quality ratings are presented in Table 2.

Results

National distribution

In total, 19 studies fulfilled the eligibility requirements and were included in the analysis, with the majority originating from Iran ($n = 11$), representing 57.9% of the included studies, followed by the United States ($n = 6$, 31.6%), one study each from China and Pakistan (5.3% each). Most studies from Iran implemented short-term interventions (8–12 weeks), while four of the six studies from the United States involved medium- to long-term interventions (5 months to 5 years). The publication years ranged from 1997 to 2025, with nine studies (47.4%) published in the past five years (2020–2025); all of these

Table 1 Data extraction included in the study

Author/Year/Country	design	Sample / Intervention	Intervention	Measures / Variables	Outcome
HERRICK et al. 2012,[35] USA	QE	Typically developing children In the 5th grade of primary school. *N* = 100,male = 45,female = 55, SPARK = 48 Con = 52 M = 10.9	5 months, 5 times/week, 30 min/time. SPARK structured curriculum Con: Non-structural free activities.	PA BMI cardiorespiratory fitness (VO_2) (Physical fitness)	SPARK↔=control↔
Gill et al., 2019,[41] USA	RCT	Typically developing middle school-aged children, *N* = 561, NR. 1.5-year intervention, urban low-income group. SPARK = 287 Con = 274 M = 12.5	One academic year; 2–5 PE classes per week. SPARK group: Adopt the SPARK Physical Education curriculum for middle schools, which includes physical activities, gamified teaching, group cooperative teaching, and diverse activities. Maintain a high level of physical activity. Con: Regular physical activities	PA(Physical fitness)	SPARK↔=Con↔
Mostafavi, R.et al. 2013,[43] Iran	RCT	Typically developing children. *N* = 90, NR. SPARK = 30 Gymnastic = 30 Routine = 30 M = 4–6	8 week, 3times/week. SPARK group: A structured curriculum, using a A combination of sports play and entertainment. Gymnastics group: CON: Non-structural free activities.	(TGMD)-2 (motor skills)	SPARK↑> Gymnastic↔=Con↔
Chen et al. 2017,[36] USA	QE	Typically developing children. *N* = 65,male = 25,female = 40. SPARK = 29 AVG = 36 M = 9.1	6 weeks,40 min/time,3 times/Week. SPARK group: The K-5 curriculum covers various activities like Snakes and Lizards, Builders and Bulldozers, Hospital Tag, etc. Kinect AVG group: Features games Zumba Kids and Just Dance.	Endurance Run BMI PA Muscle Strength (Physical fitness)	AVG↑> SPARK↑ PA ↔ BMI↔
Sallis et al. 1997,[52] USA	QE	Typically developing children. *N* = 955, NR. SPARK-1(Specialist - led group:) = 264 SPARK-2(Teacher - led group) = 331 Con: usual physical education programs = 360 M = 10	2 years, 30 min/time, 3times/week. SPARK group: The main Activities are games and exercises such as relay races, obstacle courses, and ball games. Con: Regular physical activities	PA Cardiovascular endurance Muscular strength and endurance Flexibility (Physical fitness)	PA: SPARK1↔=SPARK-2↔=Con↔ Cardiovascular endurance: SPARK1↑> SPARK-2↔=Con↔ Muscular strength and endurance: SPARK1↑> SPARK-2↔=Con↔ Flexibility: SPARK1↔=SPARK-2↔=Con↔
Fu et al. 2016,[56] USA	QE	Typically developing middle school-aged children. *N* = 174,male = 82,female = 92. SPARK = 82 Con = 92 M = 12.1	9week,40 min/time, 3times/week. SPARK Main activities include a variety of sports activities, such as football, rugby, ultimate frisbee, relay races, obstacle races, ball games, etc. Con: traditional sports programs.	PA Cardiorespiratory endurance (Physical fitness)	PA: SPARK↑> Con↔ endurance(boys): Con↑> SPARK↑ endurance(girl): SPARK↑> Con↑

Table 1 (continued)

Author/Year/Country	design	Sample / Intervention	Intervention	Measures / Variables	Outcome
Najafabadi, M. G.et al. 2018,[44] Iran	RCT	Children with ASD. *N* = 26, NR. SPARK = 12 Con = 14 M = 8.07	12week,40 min/time, 3times/ week. It consists of two parts: stability and displacement. It includes aerobic dance, running games, rope skipping, etc. The skill part covers football, basketball, frisbee, etc. Con: Regular physical activities	BOTMP test (motor skills) Questionnaire: GARS-2 (Social skills)	Motor skill: SPARK↑> Con↔ Social skills: SPARK↑> Con↔
Dehghani et al. 2023,[59] Iran	RCT	Children with ASD. *N* = 24, all male. SPARK group = 12 Con group = 12 M = 9.4	8 weeks,45 min/time,3 times/ Week. SPARK group: aerobic dance, skipping rope, running games, football, basketball, frisbee. Con: Non-structural free activities.	Gait: Heel pressure & vertical GRF: Lower-limb strength (Motor Skills)	SPARK↑ > Con↔
Hassani et al. 2022,[53] Iran	RCT	Children with ASD *N* = 30,male = 20,female = 10. SPARK = 10 ICPL = 11 Con = 9 M = 8.8	8 weeks,60 min/time,2 times/ week. SPARK group: Basic motor skills training (such as balance, running, jumping, throwing, and kicking, etc.). ICPL group: Games and visual aids: Visual cards, letter bean bags, foam dice, etc. Con: Non-structural free activities.	BOTMP test (motor skills)	ICPL↑ > SPARK↑ > Con↔
Rafiei et al. 2021,[57] Iran	RCT	Children with ASD *N* = 60,male = 57,female = 3. SPARK = 20 Kinet = 20 Con = 20 M = 8.1	8week,35 min/time, 3times/week. Spark group: Activities using different balls and rackets; 10 min of balance training. As the course progresses, the intensity of the physical activities gradually increases. Kinect: Kinect tennis games. In the games, players make correct tennis hitting movements. Con group: Non-structural free activities.	MABC − 2 Manual dexterity, Aiming and catching, Balance. (motor skills)	Aiming and catching: SPARK↑> Kinect↔=Con↔ Manual dexterity and Balance: SPARK↔=Kinect↔=Con↔
Ahmad et al. 2023,[51] Pakistan	RCT	Children with ASD *N* = 18,male = 10,female = 8. SPARK = 9 FMS = 9 M = 7.5	10week,60 min/time, 3times/ week. SPARK group: It mainly includes physical fitness and motor skill development, as well as group activities. FMS group: Fundamental motor skills, such as running, jumping, throwing, etc., to improve performance in group activities.	Questionnaire: (GARS-2) (social skills)	SPARK↑> FMS↑
Eshkil et al. 2023,[54] Iran	Pre-post test	Children with CysticFibrosis *N*=20,male=13, female=7. SPARK=20 Non-Con M=9.85	12 Weeks, 45min/time,3times/ week.SPARK group: Main Activities include activities of movement skills, aerobic games, walking or jogging, aerobic dance, skipping rope, as well as activities of manipulation skills.NO control group	lung volumes(Physical fitness)	SPARK↑ > Con↔

Table 1 (continued)

Author/Year/Country	design	Sample / Intervention	Intervention	Measures / Variables	Outcome
Bodeng 2017,[55] China	QE	Children with a Learning disorder *N*=21,male=10, female=11, SPARK=11 Con=10 M=6.16	8 Weeks, 45min/time, 3times/ week.SPARK group: Main Activities include displacement skills such as running, jumping, etc., and manipulation skills (such as grasping, throwing, etc.)Con: Non-structured routine activities	BOTMP test（motor skills）	SPARK↑>Con↔
Harzandi et al. 2022,[63] Iran	RCT	Children with Intellectual disability, female. *N*=45, all female, SPARK=15 Brain=15 Con=15 M=10.1	8 weeks, 45min/time,3times/ week.SPARK group: Main Activities: including movement skills and Manipulation skills.Brain Gymnastics Group： Activities cover Lazy 8, Cross Crawl, various crawls, Neck Rolls, Think of an X, Double Doodle, Rocker, Belly Breathing, multiple energy-related moves (Energizer, Calf Pump, etc.), different button-related actions (Brain Buttons, etc.), and others like Drink Water, Energy Yawn, etc.Con: Non-structural free activities.	BOTMP test（motor skills）	SPARK↑> Brain↑> control↔
Kosari et al. 2013,[60] Iran	QE	Children with ADHD. *N*=20, all male. SPARK=10 Con=10 M=8.8	18 sessions (45 min / Time),frequency NR.SPARK group: Main Activities include games for motor skill development, such as relay races, obstacle races, ball games, etc. Manipulation skills include grasping, throwing, catching, balance exercises, etc. Con: Regular physical activities	BOTMP test（motor skills）	SPARK↑> Brain↑> control↔
Dana et al. 2020,[61] Iran	QE	Children with Neuropsychological Learning Disabilities *N*=30, all male. SPARK=15 Con=15 M=7.76	12week,45min/time, 3times/ week.Mobility skill exercises, including long jumps, running, and hopping on one foot; Manipulation skill exercises, including catching balls, throwing balls over the head, rolling balls on the ground and between the legs, etc.Con: Regular physical activities	(TGMD)-2 （motor skills）	SPARK↑> Gymnastic↔=Con↔
Mir, N et al. 2023, [62] Iran	QE	Children with-trainable mental disabilities *N*=30, all male. SPARK=15 Con=15M=7	8week,60min/time, 3times/week. SPARK group: Games involving locomotor skills and activities related to manipulative skills.Con: Regular physical activities	BOTMP test（motor skills）	SPARK↑>Con↔

Table 1 (continued)

Author/Year/Country	design	Sample / Intervention	Intervention	Measures / Variables	Outcome
Mohammadzadeh, S.et al. 2025, [64] Iran	RCT	Children withcoordination disorder *N*=30, all female. SPARK=15 Con=15 M=10.7	8- week,45 minutes/time, 3 times/week.Spark group: Warm-up. Balance and locomotor training+object training. Cool-downCon: Regular physical activities	BOTMP test（motor skills）	SPARK↑>Con↔
Laura, M.L.et al. 2017, [58] USA	QE	Children with Obesity. *N*=435, NR. SPARK=not mentioned Con=not mentioned M=3.5	5-year intervention, 3 times a week. 30 minutes each time. The PE curriculum for grades K-2 is carried out 3 times a week throughout the year, 30 minutes each time, and is divided into two parts: health-fitness activities and skill-fitness activities.Con group: Receive non-nutritional community-based interventions	PA BMI(Physical fitness)	PA\BMISPARK↑>Con↔

Symbols: ↑, significant within-group improvement from pretest to post-test; ↔, non-significant within-group change; >, statistically significant greater improvement in the first group than the second group; =, non-significant between-group difference after the intervention

Abbreviations: *SPARK* experimental group receiving the SPARK curriculum, *Con* control group, *AVG* active videogame intervention, *ICPL* I Can Have Physical Literacy game, *Brain* Brain Gymnastics program, *Gymnastics* gymnastics program, *Kinet* Kinect exergaming intervention, *FMS* fundamental motor skills, *BOTMP* Bruininks–Oseretsky Test of Motor Proficiency, *TGMD-2* Test of Gross Motor Development, Second Edition, *MABC-2* Movement Assessment Battery for Children, Second Edition, *GARS-2* Gilliam Autism Rating Scale, Second Edition, *M* mean age, *ASD* autism spectrum disorder, *ADHD* attention-deficit/hyperactivity disorder

studies were conducted in Iran, indicating increased recent publication activity in that region.

Sample characteristics

This systematic review included 19 studies comprising a total of 2,734 participants. Of these, 1,036 participants were male, and 1,011 were female. Gender information was not reported for 687 participants (25.12%). Sample sizes varied across studies, ranging from 18 participants [51] to 955 participants [52], with an average sample size of approximately 143 participants per study.

The distribution of participants by gender differed across studies. Ten studies included mixed-gender samples [35, 36, 51–58]. Four studies included only male participants [59–62], and two studies included only female participants [63, 64]. Three studies did not report gender information [41, 43, 44].

Participants ranged from 3 to 18 years. Six studies included typically developing children [35, 36, 41, 43, 52, 56]. The remaining studies focused on children with special needs or specific health conditions, most commonly autism spectrum disorder (ASD) [44, 51, 53, 57, 59]. Other populations included children with obesity [58], cystic fibrosis [54], learning disabilities [55], intellectual disabilities [63], attention deficit hyperactivity disorder (ADHD) [60], neurological disorders [61], trainable mental disorders [62], and developmental coordination disorder (DCD) [64].

Interventions characteristics

Intervention duration. Intervention durations ranged from 6 weeks to 5 years. For descriptive purposes, interventions were categorized as short-term (≤ 12 weeks), medium-term (> 12 weeks and < 1 year), and long-term (≥ 1 year). This grouping was informed by the distribution of durations in the included studies and is consistent with common reporting windows in school-based physical education research. Most studies (15/19, 78.9%) implemented short-term interventions lasting 6–12 weeks. One study fell into the medium-term category (5 months) [36], and three studies employed long-term interventions ranging from 1.5 to 5 years [41, 52, 58]. One quasi-experimental study reported a dose of 18 sessions (45 min per session) but did not specify the weekly schedule; therefore, the calendar duration in weeks could not be confirmed from the primary report [60].

Training frequency and session duration. Seventeen studies (89.5%) implemented SPARK sessions three times per week. One study delivered two sessions per week, and one reported a variable frequency of 2–5 sessions per week.

Session duration ranged from 30 to 60 min, with 45-minute sessions being the most common format (n = 8).Intervention content and study design. Eleven studies (57.9%) primarily targeted motor skill outcomes [43, 44, 53, 55, 59–64], seven focused on physical fitness outcomes [35, 36, 41, 52, 54, 56, 58], and two examined social skills [44, 51]. Regarding study design, nine studies were randomized controlled trials, nine were quasi-experimental, and one employed a single-group pre–post design.

Overall, short-term, higher-frequency delivery formats were reported most often. Studies using these schedules

Table 2 Methodological quality of included studies based on the PEDro scale

Sources	1	2	3	4	5	6	7	8	9	10	11	Score
Chen et al. (2017) [36]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Dehghani et al. (2023) [59]	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8
Hassani et al. (2022) [53]	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	7
Eshkil et al. (2023) [54]	Y	N	N	Y	N	N	Y	Y	N	N	Y	4
Bodeng (2017) [55]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Harzandi et al. (2022) [63]	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	6
Herrick et al. (2012) [35]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Laura et al. (2017) [58]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Ahmad et al. (2023) [51]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Mostafavi et al. (2013) [43]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Sallis et al. (1997) [52]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Najafabadi et al. (2018) [44]	Y	Y	N	Y	N	N	Y	Y	N	Y	Y	6
Dana et al. (2020) [61]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Gill et al. (2019) [41]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Kosari et al. (2013) [60]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Fu et al. (2016) [56]	Y	N	N	Y	N	N	N	Y	N	Y	Y	4
Rafiei et al. (2021) [57]	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Mir et al. (2023) [62]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5
Mohammadzadeh et al. (2025) [64]	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5

Table 2 summarizes the methodological quality of the included studies as assessed using the PEDro scale. The assessment covered 11 items, including specification of eligibility criteria, random and concealed allocation procedures, baseline comparability, blinding of participants, therapists, and outcome assessors, adequacy of follow-up (≥ 85%), use of intention-to-treat analysis, between-group statistical comparisons, and reporting of point estimates with measures of variability. Each fulfilled criterion, with the exception of eligibility criteria, contributed one point to the total PEDro score, yielding a possible range from 0 to 10

also frequently reported improvements in motor and fitness outcomes, and the schedules fit within typical school timetables.

Effects on physical fitness

Three studies examined the effects of SPARK on body mass index (BMI) [36, 58, 61], and none reported statistically significant changes. Five studies assessed physical activity levels [35, 36, 41, 52, 56], two reported significant increases [52, 56], whereas three reported no significant changes [35, 36, 41].Five studies evaluated cardiopulmonary endurance [35, 36, 52, 54, 56]. Four studies reported significant improvements [36, 52, 54, 56], and one study reported no significant effect [35]. One of these studies also assessed muscular strength and reported significant improvements [36]. Only one study included flexibility as an outcome measure [52]; however, flexibility outcomes were not reported in sufficient detail to allow firm interpretation.

Overall, results were most consistently favorable for cardiorespiratory endurance and strength, while evidence for BMI and flexibility was limited.

Effects on motor skills

Eleven studies evaluated motor skill outcomes, including locomotor skills, manipulative skills, balance, coordination, and overall motor competence. Reported intervention duration varied from 8 weeks to 5 years; one study reported 18 sessions without specifying the calendar duration in weeks [60]. Samples included both typically developing children and children with special needs.

Locomotor skills

All 11 studies reported significant improvements in locomotor outcomes, including indicators such as running speed, jumping distance, hopping stability, lateral movement coordination, and walking-related measures [43, 44, 53, 55, 59–64]. The most commonly used assessment tool was the Test of Gross Motor Development–2 (TGMD-2). In addition, one study assessed walking performance in children with ASD using infrared timing gates and plantar pressure plates to quantify ground reaction forces and foot pressure. Beyond TGMD-2, motor proficiency was also assessed using the Bruininks–Oseretsky Test of Motor Proficiency (BOTMP) in one study [60] and the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) in two studies [53, 62], depending on the outcome focus and study population.

Manipulative skills

Four studies examined manipulative skill outcomes. One used the TGMD-2 [61], two used the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) [53, 62], and one used the Movement Assessment Battery for Children–2 (MABC-2) [57]. Improvements were reported in manual dexterity, throwing accuracy, catching response, and control of kicking force.

Effects on social skills

Of the 19 studies included, two investigated the effects of the SPARK program on social outcomes in children with autism spectrum disorder (ASD) [44, 51]. Both studies employed standardized autism-related assessment tools, including the Gilliam Autism Rating Scale–Second Edition (GARS-2), to evaluate changes in social interaction and communication.

Najafabadi et al. (2018) [44] assessed social skill indicators such as peer interaction during team activities and conflict resolution, reporting significant improvements in social skills among participants in the intervention group ($p = 0.01$). Ahmad et al. (2023) [51] examined stereotyped behaviors, communication abilities, and social interaction and found significantly greater improvements in communication outcomes in the SPARK group compared with controls.

Overall, both studies reported favorable social outcomes following SPARK-based interventions, while no included study examined social skill outcomes in typically developing children.

Assessments of methodological quality, risk of bias, and certainty of evidence

Methodological Quality (PEDro Assessment): The 19 included studies reported PEDro scores ranging from 4 to 8, reflecting an overall moderate level of methodological quality (S1 Table). Common methodological shortcomings included the absence of participant and therapist blinding, incomplete follow-up, and limited use of intention-to-treat analyses.

Risk of Bias: Risk of bias was evaluated using the RoB 2 tool for randomized controlled trials and the ROBINS-I tool for non-randomized studies. Most RCTs were judged to have some concerns, whereas non-randomized studies were generally at a serious risk of bias, primarily due to confounding factors and selective outcome reporting (S2 Table).

Certainty of Evidence (GRADE Assessment): According to the GRADE approach, the certainty of evidence for improvements in motor skills was rated as moderate, while that for physical fitness and social skills was rated as low, mainly due to study limitations, inconsistency, and imprecision (S3 Table).

Overall, the SPARK intervention demonstrated potential benefits in enhancing children's motor skills; however, evidence for its effects on physical fitness and social skills remains less certain due to methodological constraints and variability among studies.

Discussion

The studies included in this review involved both typically developing children and children with special needs or clinical conditions. Because these groups differ substantially in baseline motor competence, participation barriers, and support requirements, combining them within a single analytical framework may mask important differences and complicate the interpretation of the findings. For this reason, the evidence is discussed separately for typically developing children and for children with special needs, allowing for a more precise interpretation of the effects of the SPARK program across populations.

Geographic distribution and external validity

The available evidence is geographically concentrated, with more than half of the included studies conducted in Iran and nearly one-third in the United States, while research from other regions, such as China and Pakistan, is scarce. This imbalance has important implications for the interpretation of the findings. On the one hand, the results largely reflect the educational contexts and implementation conditions of a limited number of countries, which may limit their generalizability. On the other hand, intervention duration differs notably across regions: studies conducted in Iran typically implemented short-term programs lasting 8–12 weeks, whereas studies from the United States more often examined interventions extending over several months or years. This variation highlights the need for additional research conducted across diverse geographic and cultural settings to strengthen the external validity of the evidence on SPARK intervention outcomes.

Population-specific implications

The studies included in this review encompassed both typically developing children and children with a range of special needs or health conditions. Because these populations differ considerably in baseline physical activity levels, participation constraints, and the types of support required, discussing them together may reduce the practical relevance of the findings. The results are considered separately for typically developing children and for children with special needs or health conditions. In addition, factors such as gender, age, baseline physical activity, and other potential moderators should be taken into account, as they may further influence the observed effects of the SPARK intervention.

Fischbein et al. (2016) [65] examined the implementation of the SPARK program in early childhood education settings and reported improvements in both motor skills and social functioning among participating children [65]. These findings are consistent with the broader patterns identified in the present review and suggest that SPARK may be a useful intervention in early childhood contexts, particularly with respect to motor development and social interaction. The results also indicate that the program may apply to children with diverse developmental profiles, especially during the preschool years.

Sex reporting and practical implications

Across the included studies, 1,036 participants were male, and 1,011 were female, while sex was not reported for 687 participants (25.12%). Sex reporting was also uneven at the study level, with several studies recruiting single-sex samples and others not specifying sex. Importantly, most primary studies did not present outcomes stratified by sex, nor did they test sex as an effect modifier. As a result, this review cannot draw evidence-based conclusions about whether SPARK effects differ between boys and girls.

From an interpretation and implementation standpoint, the main implication is that the current evidence can inform mixed school settings in general, but it is not sufficiently detailed to support sex-specific expectations or adaptations. Future trials would strengthen the evidence base by reporting sex distribution consistently, presenting sex-disaggregated outcomes where feasible, and pre-specifying moderator analyses to clarify whether program effects vary by sex.

Children with special needs

A considerable proportion of the SPARK literature in this review involved children with special needs or health conditions, most commonly children with autism spectrum disorder (ASD) [44, 51, 53, 57, 59], but also children with attention-deficit/hyperactivity disorder (ADHD) [60], intellectual disabilities [63], learning disabilities [55], developmental coordination disorder [64], neurological disorders [61], trainable mental disabilities [62], cystic fibrosis [54], and obesity [58]. In these groups, challenges in coordination, balance, motor planning, attention regulation, endurance, or communication may shape how students participate in PE and may influence which outcomes are most sensitive to change.

From an implementation perspective, the practical implication is that intervention effects in special-needs populations should be interpreted alongside the likely need for adaptation and support. SPARK is often delivered in a structured format with repeated practice and progression of task difficulty, which may be compatible with inclusive PE contexts where predictable routines and graded tasks can support engagement. However, the available studies rarely consistently report baseline functional status and seldom provide comparable subgroup analyses, so this review cannot determine whether effects differ systematically across diagnoses or levels of impairment. Social outcomes illustrate this limitation clearly: only two studies assessed social functioning, and both

were conducted in children with ASD [44, 51], which is insufficient to generalize social effects to other groups.

Typically developing children

Six studies recruited typically developing samples [35, 36, 41, 43, 52, 56]. In this population, variation in outcomes is less likely to reflect diagnosis-related functional constraints and may instead depend on factors such as baseline activity exposure, general conditioning, and how consistently the program is delivered. Across typically developing samples, motor outcomes were commonly reported as improved, while fitness-related findings were more variable across studies. It is also important that sex/gender and other subgroup results were not consistently reported across the evidence base, which limits any attempt to infer differential effects by sex/gender, region, or other moderators.

For practice, the most defensible interpretation is that SPARK can be viewed as a feasible, structured option for routine PE in typically developing populations, with its clearest alignment to movement competence outcomes. At the same time, because few studies provide head-to-head comparisons with alternative PE curricula using comparable outcomes, the current literature does not allow firm conclusions about whether SPARK offers advantages over other well-designed PE approaches in typically developing settings. Curriculum choice in these settings should therefore be guided by local instructional goals (e.g., skill development versus broader health targets), feasibility, and delivery capacity, rather than expectations of program-specific superiority.

Duration and dose: implications for implementation and interpretation

Most included studies evaluated SPARK using short-term implementations (6–12 weeks; 15/19, 78.9%), with only one medium-term intervention (5 months) and three long-term implementations (≥ 1 year). Training frequency was most commonly three sessions per week (17/19, 89.5%), and session duration typically ranged from 30 to 60 min, with 45 min most frequently reported.

However, the current evidence base is not well suited to drawing dose–response conclusions. Calendar duration was not consistently reported in comparable terms (e.g., one study reported total sessions without specifying weekly frequency, which prevents conversion to weeks), and implementation fidelity and total exposure time were often insufficiently described, which is a common barrier to dose–response inference in intervention reviews [66]. In addition, the small number of long-term studies limits inference regarding maintenance and sustainability beyond short-term units. Importantly, these observations are descriptive in nature and should not be interpreted as evidence of an optimal dose, threshold, or comparative effectiveness across different implementation durations or frequencies. Therefore, the most defensible interpretation is that SPARK has been evaluated predominantly in feasible short-term school formats, while evidence for sustained, long-term implementation remains limited. From an implementation standpoint, these constraints are consistent with broader challenges in school-based interventions and cluster trials [67].

Interpreting outcomes by domain

Motor skills

Motor outcomes were the most frequently assessed, and improvements in locomotor indicators were reported consistently across studies examining motor competence [43, 44, 53, 55, 59–64]. This pattern is implementation-relevant because movement competence can shape how confidently students participate in PE activities and how inclusive lessons are for students with different starting skill levels. Although the underlying designs do not support strong causal inference, the findings are broadly consistent with the view that structured practice opportunities and repeated exposure to fundamental movement tasks may be beneficial in school settings.

Interpretation is complicated by measurement heterogeneity. Many studies relied on the Test of Gross Motor Development–2 (TGMD-2), whereas others used broader proficiency measures such as the Bruininks–Oseretsky Test of Motor Proficiency (e.g., BOT-2/BOTMP), which emphasize somewhat different subdomains and limit direct comparability across studies [53, 61, 62]. Greater consistency in outcome selection and reporting (including subscale-level detail) would strengthen future syntheses and clarify which motor components are most responsive to SPARK-based delivery.

Physical fitness and physical activity

Fitness-related findings were most consistent for cardiorespiratory endurance: four of five studies assessing endurance reported improvements [36, 52, 54, 56], whereas one reported no significant effect [35]. Evidence related to muscle strength remains limited; however, the studies that assessed this outcome generally reported favorable trends [36]. Results for physical activity levels were mixed, with some studies noting increases [52, 56] and others reporting no statistically significant changes [35, 36, 41]. Such variability is likely influenced by differences in assessment methods, baseline activity levels, and the degree to which interventions were implemented as intended, rather than reflecting a consistent absence of effect. With respect to body mass index (BMI), studies that included this outcome did not identify significant changes following the intervention [36, 58, 61]. Flexibility was assessed in relatively few studies, and the available evidence is too limited to support firm conclusions [52].

From an applied perspective, these findings suggest that when SPARK is delivered exclusively within the context of physical education (PE), its effects appear more consistently associated with movement competence and certain fitness-related outcomes, whereas effects on BMI-related indicators are less evident.

Social outcomes

Of the included studies, only two examined social outcomes, and both reported improvements following the intervention [44, 51]. While these findings are suggestive, the limited evidence base makes it difficult to draw definitive conclusions about the impact of the SPARK program on social outcomes across different populations or age groups.

Furthermore, social outcomes were primarily assessed using parent- or teacher-reported indicators, which may be susceptible to expectancy effects and may not fully capture children's social interactions outside the intervention context. Future studies would benefit from the use of multiple data sources or direct observational methods, as well as the inclusion of follow-up assessments, to enhance the reliability and interpretability of findings related to social outcomes. Therefore, these findings should be interpreted with caution.

Methodological implications and interpretation of findings

The methodological quality appraisal and risk of bias assessment highlight several limitations within the current evidence base for SPARK interventions. Most included studies achieved moderate PEDro scores, with common concerns related to the absence of blinding, incomplete follow-up, and potential selective reporting. Such limitations are not uncommon in school-based educational research, where cluster-based delivery models and participant blinding are often impractical. As noted by Stratton (2019), quasi-experimental designs, particularly those relying on pre- and post-intervention comparisons, are frequently adopted in educational contexts where randomization is difficult to implement [68]. While these designs allow interventions to be evaluated under real-world conditions, they also introduce vulnerabilities to selection bias, attrition, and variability in implementation, all of which were evident to varying degrees in the studies included in this review. These factors may partially account for the heterogeneity observed across outcomes and warrant caution when interpreting the strength of the evidence.

Despite these methodological constraints, a consistent pattern emerged across studies with respect to motor skill outcomes. The direction of effects generally favored SPARK participation, and the GRADE assessment classified the quality of evidence for motor skills as moderate, reflecting a reasonable level of consistency despite study-level limitations [69]. In contrast, evidence related to physical fitness and social outcomes was rated as low, largely due to small sample sizes, elevated risks of bias, and imprecise outcome estimates. Although a small number of studies reported improvements in social outcomes, these findings were based on limited samples and measurement approaches that increase the likelihood of bias, underscoring the need for cautious interpretation [70, 71].

From a practical standpoint, these patterns suggest that SPARK is most reliably aligned with improvements in motor skill development, which is a core objective of physical education curricula, particularly in elementary and early childhood settings. However, the evidence is less consistent for broader outcomes such as physical fitness and social development. This distinction is important for schools and physical education teachers when setting expectations for program implementation. When SPARK is used as a standalone physical education curriculum, it appears well-suited for supporting movement competence but should not be expected to produce substantial changes in fitness-related indicators or social outcomes without additional, targeted support.

Accordingly, schools whose primary objectives extend beyond motor skill development, such as improving cardiorespiratory fitness, addressing weight-related outcomes, or promoting social and behavioral skills, may need to complement SPARK with other evidence-based interventions that are specifically designed to target these domains [72]. In this sense, SPARK may function most effectively as a foundational component within a broader, multi-component school-based physical activity strategy rather than as a comprehensive solution for all physical and psychosocial outcomes.

Future research would benefit from addressing the methodological limitations identified in this review through the use of more rigorous study designs, including randomized controlled trials with transparent allocation procedures and standardized outcome measures. Larger sample sizes, longer follow-up periods, and strategies to reduce attrition would also strengthen confidence in estimates of intervention effects and help clarify whether observed improvements are sustained over time. Such advances would provide clearer guidance for educators and policymakers considering the integration of SPARK into physical education curricula.

Overall, the available evidence indicates that SPARK has a meaningful role in supporting motor skill development within school-based physical education programs. However, conclusions regarding its impact on physical fitness and social outcomes remain tentative due to methodological constraints and limited evidence. Until more robust data are available, SPARK should be viewed as a targeted intervention that is most appropriately

applied when motor competence is a primary educational goal.

Limitations of the study

This study has several limitations that should be considered when interpreting the findings. The available evidence is geographically concentrated, with most studies conducted in Iran (57.9%) and the United States (31.6%), which may limit the applicability of the results to other educational systems and cultural contexts. In addition, participant representation was uneven across developmental stages and subgroups, further constraining the generalizability of the conclusions. Although the overall age range spanned 3–18 years, relatively few studies focused specifically on preschool-aged children (3–6 years) or older adolescents (14–18 years), and several special populations (e.g., obesity, cystic fibrosis) were represented by only single studies, limiting confidence in population-specific inferences.

Third, the intervention evidence was dominated by short-term implementations (commonly 6–12 weeks), with comparatively few long-term studies (≥ 1 year). Training schedules were also relatively clustered around feasible school formats (most commonly three sessions per week, with sessions typically 30–60 minutes and 45 min most frequently reported), which supports feasibility but restricts evaluation of alternative delivery models and dose–response patterns. Moreover, calendar duration was not always reported in comparable terms (e.g., some studies reported total sessions without specifying weekly frequency), and implementation fidelity and total exposure time were often insufficiently described, limiting interpretation of "dose" effects.

Methodologically, several studies used non-randomized or quasi-experimental designs, and blinding was rarely feasible in school-based PE interventions. Consistent with known constraints in school-based and cluster trial research, risks of contamination, variability in delivery, and practical limits on blinding may increase bias in effectiveness estimates [67, 72]. In this review, PEDro scores suggested moderate methodological quality overall, while RoB 2/ROBINS-I assessments indicated at least some risk of bias in multiple studies. According to the GRADE evaluation, the certainty of evidence was moderate for motor outcomes but low for physical fitness and social outcomes, primarily due to study limitations and imprecision.

Finally, outcome measurement was heterogeneous across studies, and some outcomes were infrequently assessed. For example, BMI was assessed in only three studies and showed no significant change [36, 58, 61], and flexibility was measured in only one study with insufficient detail reported [52]. Social outcomes were evaluated in only two studies, both conducted in children with ASD [44, 51], limiting generalizability to other populations.

Conclusion

This systematic review synthesized evidence from 19 studies examining the effects of the SPARK program in children and adolescents. Overall, the available evidence suggests that SPARK participation is associated with improvements in motor skill outcomes and selected fitness indicators, particularly cardiorespiratory endurance [35, 36, 52, 54, 56] and locomotor-related motor performance [43, 44, 53, 55, 59–64]. In contrast, evidence for BMI and flexibility remains limited, with no significant BMI changes reported in the studies that assessed BMI [36, 58, 61] and insufficient reporting for flexibility [52]. Evidence regarding social outcomes is currently sparse and limited to two studies in children with ASD, both reporting favorable findings [44, 51]; therefore, broader conclusions about social–emotional effects across general school populations remain premature.

Methodological appraisal indicated moderate overall study quality, and GRADE ratings suggested moderate certainty for motor outcomes but low certainty for physical fitness and social outcomes. Within these evidentiary boundaries, SPARK can be considered a feasible, evidence-informed PE curriculum option for schools seeking to enhance movement competence and endurance-related fitness within routine timetables, while expectations for BMI change or broad social outcomes should remain cautious unless supported by additional, complementary components.

Future research would be most informative if it included rigorously designed trials with transparent reporting of dose and fidelity, standardized assessment approaches, and longer follow-up to evaluate maintenance. From a practical perspective, such evidence is particularly needed to clarify which student populations benefit most from SPARK and under what implementation conditions, including underrepresented regions, age groups (particularly preschoolers and older adolescents), and diverse special populations, to strengthen external validity and inform context-sensitive application.

Supplementary Information

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Supplementary Material 1: PRISMA 2020 checklist.

Supplementary Material 2: Numbering table.

Supplementary Material 3: The PRISMA flowchart.

Supplementary Material 4: Risk of Bias Assessment.

Supplementary Material 5: GRADE Summary of Findings for Included Outcomes.

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Authors' contributions
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Data availability
All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
Not applicable. This study is a systematic review based exclusively on published literature and did not involve the collection of primary data from human participants. Therefore, ethical approval and consent to participate were not required.

Consent for publication
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Competing interests
The authors declare no competing interests.

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